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Vascular Surgery Patients at Risk for Malnutrition Are at an Increased Risk of Developing Postoperative Complications

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Background: Malnutrition is an important risk factor for adverse postoperative outcomes such as infection and delayed wound healing, often resulting in longer hospital stay and higher readmission and mortality rates. The aim of this study is to assess the relationship between the risk for malnutrition prior to elective vascular surgery and postoperative complications.

Methods: In this observational cross-sectional study, elective vascular surgery patients were included from January 2015 until November 2018. Included were percutaneous, carotid, endovascular, peripheral bypass, abdominal, lower extremity amputation, and other interventions. The patients were assessed for risk for malnutrition using the Patient-Generated Subjective Global Assessment Short Form (PG-SGA SF), whereby <4 points was defined as low risk, 4−8 points as medium risk, and ≥ 9 points as high risk for malnutrition. Postoperative complications were registered using the Comprehensive Complication Index. Univariate and multivariate analyses were performed to evaluate the relationship between risk for malnutrition and postoperative complications.

Results: Of 468 patients, 113 (24.1%) were found to be at risk for malnutrition (PG-SGA SF ≥ 4 points). Occurrence of postoperative complications (23.9% in the low risk vs. 51.9% in the high risk group, $P = 0.006$), length of hospital stay (5.5 ± 4.3 days in the low risk vs. 8.2 ± 5.1 in the high risk group, $P = 0.005$), 30-day readmission (4.7% in the low risk vs. 19.2% in the high risk group, $P = 0.009$), and Comprehensive Complication Index (median score of 0 in the low risk vs. 8.7 in the high risk group, $P = 0.018$) varied significantly between the 3 PG-SGA SF groups. After multivariate analysis, the medium risk for malnutrition group had a 1.39 (95% confidence interval 1.05−1.84) times higher Comprehensive Complication Index than the low risk for malnutrition group ($P = 0.02$).

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Conclusions: Electively operated vascular surgery patients at risk for malnutrition are more likely to develop postoperative complications. This finding suggests that improving the nutritional status of vascular surgery patients prior to surgery has the potential to reduce the risk of complications.

INTRODUCTION

Malnutrition is an important risk factor for adverse postoperative outcomes such as infection and delayed wound healing, often resulting in longer hospital stay and higher readmission and mortality rates.[1–6] This is particularly the case in cardiac, hepatobiliary, and colorectal surgery, where malnutrition has been associated with an increased risk of developing postoperative complications.[7–9] But also in critical limb ischemia patients severe malnutrition has been demonstrated to be a risk factor for death at 30 days postoperatively.[10]

According to the European Society for Clinical Nutrition and Metabolism (ESPEN), malnutrition is defined as: ''A state resulting from lack of intake or uptake of nutrition that leads to altered body composition (decreased fat-free mass) and body cell mass leading to diminished physical and mental function and impaired clinical outcome from disease.''[11] Several screening tools, with varying degrees of complexity and a broad spectrum of health parameters, can be used to assess malnutrition in hospital patients, ranging from recent unintentional weight loss to more comprehensive, multidimensional instruments.[12] In many of these tools, the body mass index (BMI) plays an important role, where an elevated BMI is inversely proportional with malnutrition. As such, decreased fat-free mass, an important hallmark for malnutrition, is overlooked in patients with a high BMI.[11,13] In the vascular surgery population over 60% of the patients are classified as overweight/obese (according to BMI) and therefore, although unduly, do not meet the criteria for risk for malnutrition.[14,15] Thus, although aforementioned tools could be used to recognize present malnutrition, they do not adequately quantify risk for malnutrition.

The Patient-Generated Subjective Global Assessment Short Form (PG-SGA SF) is a tool that takes the presence of nutrition impact symptoms (i.e., factors hindering food intake) into account.[16] The PG-SGA SF not only recognizes patients with malnutrition, but also patients at risk for malnutrition. By identifying patients at risk and by optimizing predictive variables preoperatively, further deterioration of nutritional status and subsequent malnutrition may be prevented. In general surgery, cardiac, and vascular surgery patients, the prevalence of risk for malnutrition ranges from 19% to 24%.[4,7,17] Evidence for a relationship between risk for malnutrition and the occurrence of postoperative complications in elective vascular surgery patients is still lacking.

The aim of this study is to assess the relationship between the risk for malnutrition (prior to elective vascular surgery) and postoperative complications.

MATERIALS AND METHODS

Study Design

For this prospective, observational, cross-sectional study, we included all elective vascular surgery patients at the University Medical Center Groningen (UMCG), from January 2015 until November 2018, who gave oral consent and were able to complete the PG-SGA SF. There were no exclusion criteria. The majority of patients underwent surgery within 3 months after their last outpatient visit, during which the measurements for this study were performed. This study was granted dispensation for the Dutch law on scientific medical research on human beings (WMO) obligation by the Medical Ethical Committee of the UMCG (reference 2016/322). Patient data were processed and electronically stored in accordance with the Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects.[18] Data were analyzed anonymously.

Baseline Variables

Collected data included age (in years), sex, BMI, smoking (yes/no), alcohol consumption (yes/no), hypertension (yes/no), comorbidities (Charlson Comorbidity Index), type of surgery (percutaneous, carotid, endovascular, peripheral bypass, abdominal, lower extremity amputation, and other interventions), American Society of Anaesthesiologists' physical status classification system score (ASA score), hospital length of stay (days), 30-day mortality (yes/no), and 30-day readmission to the hospital (yes/no). The Charlson Comorbidity Index is a weighted score that predicts 1-year mortality for patients based on co-existing morbidities and age.[19–21]

Percutaneous interventions were classified as simple interventions (angioplasty and simple stents), endovascular interventions including endovascular aneurysm repair (EVAR), thoracic TEVAR, fenestrated EVAR, and branched EVAR.

Assessment of Risk for Malnutrition

To assess the risk for malnutrition, patients completed the PG-SGA SF Dutch version 3.7 independently. This is a simple and validated screening tool that has been demonstrated to be accurate in discriminating between patients at risk for malnutrition, and can be completed in less than 5 min.[16,22,23] It includes 4 boxes: Box 1 addresses the history of weight loss (0−5 points); Box 2 evaluates changes in food intake in the past month (0−4 points); Box 3 addresses presence of nutrition impact symptoms in the past 2 weeks (0−24 points); and Box 4 evaluates activities and function in the past month (0−3 points). In accordance with the PG-SGA triage system, a total PG-SGA SF score of 0−3 points was categorized as low risk, 4−8 points as medium risk, and ≥9 points as high risk for malnutrition.[24]

Postoperative Complications

Postoperative complications were registered and analyzed using the Comprehensive Complication Index, a tool that encompasses all postoperative complications per hospital stay with regard to their severity according to the Clavien−Dindo classification of surgical complications; it consists of 5 complication grades, including 4 subgrades.[25] The Comprehensive Complication Index takes the quantity of appearance of each complication into account, summing all the postoperative complications weighted according to their severity: ranging from 0 (no complications) to 100 (death).[26]

Statistical Methods

Categorical variables were presented as numbers and percentages. Distribution was assessed by way of a Q−Q plot or histogram. Continuous variables were presented as mean ± standard deviation for normally distributed variables and as median with interquartile range (IQR) for skewed or ordinal variables. Differences between continuous variables were tested with the analysis of variance for normally distributed data and the Kruskal−Wallis test for variables with skewed distribution. Differences between categorical variables were analyzed with the chi-squared test. Two-tailed *P*-values were used and significance was set at $P < 0.05$. To analyze the relationship between risk for malnutrition and the Comprehensive Complication Index, a linear regression model with backward selection was used. Since the Comprehensive Complication Index had a skewed distribution, the variable was transformed using the natural logarithm (*ln*-transformation). After the analysis, the resulting coefficient was transformed back to the geometric mean. Besides the univariate unadjusted analysis, a multivariate adjusted analysis was performed with the confounders age, sex, BMI, hypertension, ASA score, and type of surgery. These variables were selected based on literature and subject matter knowledge. All statistical analyses were performed with the Statistical Package for the Social Sciences (IBM SPSS Version 23.0; SPSS Inc., Chicago, IL, USA).

RESULTS

Participants and Descriptive Data

A total of 468 patients with a mean age of 67.8 ± 9.9 years were included, of which 335 were men (71.6%). Baseline characteristics are listed in Table I, with the patients stratified for risk for malnutrition. Three hundred fifty-five patients (75.9%) were found to be at low risk for malnutrition, 86 patients (18.4%) were estimated as medium risk, and 27 patients (5.8%) at high risk for malnutrition. In total, 113 patients (24.1%) were at medium-high risk for malnutrition. In the high risk for malnutrition group, there were significantly more women than in the low and medium risk groups ($P = 0.001$). Also, in the medium and high risk for malnutrition groups the median ASA score was significantly higher (respectively 3 [IQR 2−3] and 3 [IQR 3−3]) in comparison with the low risk group (2 [IQR 2−3], $P < 0.001$). The Charlson Comorbidity Index did not differ significantly between the groups ($P = 0.212$).

Table II shows median box scores of the PG-SGA SF categorized per risk for the malnutrition group. The median PG-SGA SF score of all patients was 1 (IQR 0−3), with scores ranging from 0 to 18. The median score for history of weight loss (Box 1) was 0 (IQR 0−0); changes in food intake (Box 2) was 0 (IQR 0−0); for nutrition impact symptoms (Box 3) was 0 (IQR 0−1); and for activities and function (Box 4) was also 0 (IQR 0−1).

Relationship between Risk for Malnutrition and Postoperative Complications

The data on risk for malnutrition and postoperative complications are shown in Table III. One hundred

Table I. Baseline characteristics categorized per risk for malnutrition group

Parameter	Low risk (PG-SGA SF[a] 0–3 points)	Medium risk (PG-SGA SF 4–8 points)	High risk (PG-SGA SF ≥9 points)	Total	*P*-value
Number	355 (75.9%)	86 (18.4%)	27 (5.8%)	468 (100%)	–
Age (years)	67.8 ± 9.9	66.3 ± 11.9	66.0 ± 12.0	67.4 ± 10.4	0.374
Sex					0.001
Male	268 (75.5%)	54 (62.8%)	13 (48.1%)	335 (71.6%)	
Female	87 (24.5%)	32 (37.2%)	14 (51.9%)	133 (28.4%)	
BMI	27.1 ± 4.8	26.6 ± 5.1	25.2 ± 5.9	26.9 ± 5.0	0.127
History of smoking	229 (66.2%)	63 (75.9%)	18 (78.3%)	310 (68.6%)	0.136
Using alcohol	145 (50.0%)	30 (41.7%)	10 (41.7%)	185 (47.9%)	0.367
Hypertension	222 (64.7%)	60 (71.4%)	19 (73.1%)	301 (66.4%)	0.386
Comorbidities[b], median (IQR)	4 (4–6)	5 (4–6)	5 (3–5)	4 (4–6)	0.212
Type of planned surgery					
Percutaneous	77 (21.7%)	17 (19.8%)	3 (11.1%)	97 (20.7%)	0.003
Carotid	65 (18.3%)	13 (15.1%)	5 (18.5%)	83 (17.7%)	
Endovascular	112 (31.5%)	24 (27.9%)	5 (18.5%)	141 (30.1%)	
Peripheral bypass	41 (11.5%)	13 (15.1%)	5 (18.5%)	59 (12.6%)	
Abdominal	29 (8.2%)	6 (7.0%)	2 (7.4%)	37 (7.9%)	
Lower extremity amputation	5 (1.4%)	1 (1.2%)	4 (14.8%)	10 (2.1%)	
Other	19 (5.4%)	11 (12.8%)	2 (7.4%)	32 (6.8%)	
ASA[c], median (IQR)	2 (2–3)	3 (2–3)	3 (3–3)	3 (2–3)	<0.001

Baseline characteristics are shown as *n* (%); continuous data as mean ± standard deviation; and ordinal and skewed data are given as median with IQR.
[a]Scored Patient-Generated Subjective Global Assessment Short Form (©FD Ottery 2005, 2006, 2015).
[b]According to the Charlson Comorbidity Index, a weighted index predicts 1-year mortality by measuring the burden of comorbidities (range 0–19).
[c]ASA score categorizes fitness of patients prior to surgery (range 0–5).

Table II. Box scores PG-SGA SFA categorized per risk for malnutrition group

PG-SGA SF group	Low risk ($n = 355$) (PG-SGA SF[a] 0–3 points) Median (IQR)	Medium risk ($n = 86$) (PG-SGA SF 4–9 points) Median (IQR)	High risk ($n = 27$) (PG-SGA SF ≥9 points) Median (IQR)	Total ($n = 468$) Median (IQR)
Box 1				
Weight history	0 (0–0)	0 (0–1)	1 (0–3)	0 (0–0)
Box 2				
Food intake	0 (0–0)	0.5 (0–1)	1 (1–3)	0 (0–0)
Box 3				
Symptoms	0 (0–0)	3 (0.75–3.75)	6 (4–7)	0 (0–1)
Box 4				
Activity/function	0 (0–1)	1 (1–3)	2 (2–3)	0 (0–1)
Total score	0 (0–1)	5 (4–6)	11 (10–14)	1 (0–3)

[a]Scored Patient-Generated Subjective Global Assessment Short Form (©FD Ottery 2005, 2006, 2015).

twenty-one patients (25.9%) had one or more postoperative complications. In the high risk for malnutrition group, 14 patients (51.6%) developed one or more postoperative complications ($P = 0.006$). The length of hospital stay significantly differed between the groups, varying from 5.5 ± 4.3 days in the low risk for malnutrition group to 8.2 ± 5.1 days in the high risk for malnutrition group ($P = 0.005$). Also, the 30-day readmission significantly differed, with 16 patients (4.7%) in the low risk and 5 patients (19.2%) in the high risk for malnutrition group ($P = 0.009$).

Table III. Postoperative complications categorized per risk for malnutrition group

PG-SGA SF[a] group	Low risk (n = 355) (PG-SGA SF 0–3 points)	Medium risk (n = 86) (PG-SGA SF 4–9 points)	High risk (n = 27) (PG-SGA SF ≥9 points)	Total (n = 468)	P-value
Occurrence of ≥1 postoperative complications	85 (23.9%)	22 (25.6%)	14 (51.9%)	121 (25.9%)	0.006
Length of hospital stay (days)	5.5 ± 4.3	6.3 ± 5.3	8.2 ± 5.1	5.7 ± 4.6	0.005
Comprehensive Complication Index[b], median (IQR)	0 (0–0)	0 (0–8.7)	8.7 (0–20.9)	0 (0–8.7)	0.018
Thirty-day readmission	16 (4.7%)	6 (4.7%)	5 (19.2%)	27 (6.0%)	0.009
Thirty-day mortality	4 (1.1%)	4 (4.7%)	0 (0.0%)	8 (1.7%)	0.060

Nominal data are gives as n (%); normally distributed continuous data as mean ± standard deviation; and ordinal and skewed continuous data as median (IQR).
[a]Scored Patient-Generated Subjective Global Assessment Short Form (©FD Ottery 2005, 2006, 2015).
[b]According to the Comprehensive Complication Index, which takes all complications after a procedure and their respective severity into account (range 0–100).

The overall median Comprehensive Complication Index was 0 (IQR 0–8.7). As shown in Table III and Figure 1, patients at low risk for malnutrition had a median Comprehensive Complication Index of 0 (IQR 0–0) and in the medium and high risk group these numbers were respectively 0 (IQR 0–8.7) and 8.7 (IQR 0–20.9) ($P = 0.018$).

Table IV shows the linear regression analysis of the relationships between risk for malnutrition and postoperative complications. The medium risk for the malnutrition group had a 1.35 (95% confidence interval [CI] 1.01–1.80) times higher Comprehensive Complication Index than the low risk for malnutrition group (reference group), and a 1.39 (95% CI 1.05–1.84) times higher Comprehensive Complication Index than the low risk for the malnutrition group when adjusted for the confounders age, sex, BMI, hypertension, ASA, and type of surgery. Both effects were statistically significant, that is, $P = 0.044$ and $P = 0.02$, respectively. There was no statistically significant difference in Comprehensive Complication Index between the high and low risk for the malnutrition group in both the unadjusted ($P = 0.28$) and adjusted analyses ($P = 0.374$).

In Table V, the multivariate linear regression analysis, comprising only major vascular procedures, is presented and shows that after adjusting for confounders, the medium risk for the malnutrition group had a significantly ($P = 0.032$) higher Comprehensive Complication Index than the low risk for the malnutrition group.

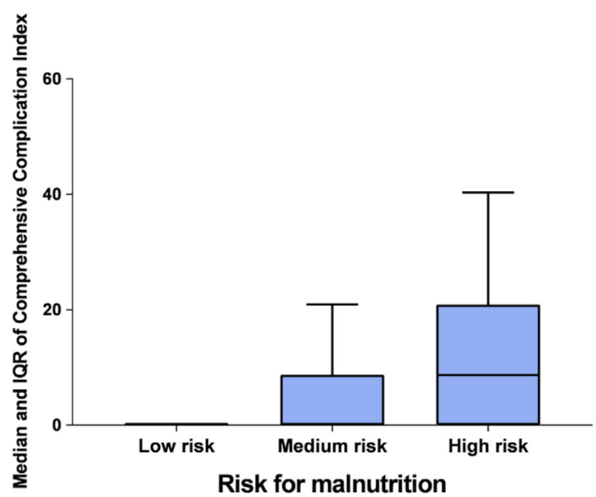

Fig. 1. Boxplot of postoperative complications, according to the Comprehensive Complication Index, categorized per risk for malnutrition group.

DISCUSSION

This study shows that electively operated vascular surgery patients with a medium risk for malnutrition are more prone to develop postoperative complications than patients with low risk for malnutrition. In the univariate analysis, the occurrence of postoperative complications, the length of hospital stay, and the Comprehensive Complication Index varied significantly between the different risks for malnutrition groups. In the multivariate analysis, the patients with medium risk for malnutrition had a 1.39 times higher Comprehensive Complication Index than

Table IV. Linear regression analysis of the relationship between risk for malnutrition and the Comprehensive Complication Index

	Unadjusted			Adjusted[a]		
Risk for malnutrition category	β[b]	95% CI	*P*-value	β[b]	95% CI	*P*-value
Low risk for malnutrition (PG-SGA SF 0−3 points)	Reference			Reference		
Medium risk for malnutrition(PG-SGA SF 4−8 points)	1.35	1.01−1.80	0.044	1.39	1.05−1.84	0.020
High risk for malnutrition (PG-SGA SF ≥9 points)	0.82	0.60−1.39	0.280	0.86	0.60−1.20	0.374

[a]Adjusted for age, sex, BMI, hypertension, ASA, and type of surgery.
[b]Transformed back.

Table V. Linear regression analysis of the relationship between risk for malnutrition and the Comprehensive Complication Index—only major vascular procedures[a]

	Unadjusted			Adjusted[b]		
Risk for malnutrition category	β[c]	95% CI	*P*-value	β[c]	95% CI	*P*-value
Low risk for malnutrition (PG-SGA SF 0−3 points)	Reference			Reference		
Medium risk for malnutrition (PG-SGA SF 4−8 points)	1.37	1.00−1.87	0.053	1.38	1.03−1.85	0.032
High risk for malnutrition (PG-SGA SF ≥9 points)	0.85	0.58−1.24	0.402	0.88	0.61−1.27	0.475

[a]Excluding patients undergoing arteriovenous access surgery, percutaneous transluminal angioplasty interventions (including coil embolization), and minor amputations (forefoot amputation, digits, and wound revisions).
[b]Adjusted for age, sex, BMI, hypertension, ASA, and type of surgery.
[c]Transformed back.

the patients with low risk for malnutrition. As such, at medium risk for malnutrition patients are at a higher risk of developing more complications and/or more severe complications.

In the busy outpatient setting, methodically quantifying the nutritional status of a patient, for example, by measuring fat-free mass and/or muscle strength, has proven to be difficult.[27] As a result, nutritional status is often evaluated using body weight and/or BMI and/or albuminemia, both of which have been shown to be inadequate predictors.[28,29] The nutritional screening instrument used in this study was found to be among the few instruments covering all domains of ESPEN's conceptual definition of malnutrition.[30] Specifically, the PG-SGA SF captures changes in weight and in food intake and identifies nutrition-related impairments that can lead to future malnutrition. Herewith, the PG-SGA SF more effectively assesses the risk for malnutrition than other tools covering fewer domains (which are more suited to assessing present malnutrition). As such, with the PG-SGA SF's enhanced risk assessment capability, the implementation of preventive measures—by dieticians as well as physicians, nurses, and physiotherapists for instance—can be better facilitated, as opposed to reactive interventions when patients are already malnourished.[24]

A previous study showed that the co-occurrence of physical frailty and malnutrition was associated with a much greater increase in adverse health outcomes than malnutrition alone, suggesting that frail patients with poor nutritional status are particularly suitable candidates for preventive interventions.[31] Moreover, preoperative rehabilitation programs including endurance, strength, and high-intensity training schedules have resulted in improved postoperative clinical outcomes.[32,33] In sum, combined exercise and nutritional interventions are most likely to lead to positive results in terms of postoperative outcomes.[34]

The prevalence of risk for malnutrition that we found in our study, respectively 24.1%, was comparable with the numbers that were found in prior studies among hospitalized patients, ranging from 15–32%.[5,35,36] In general, malnutrition upon hospital admission is associated with prolonged length of stay and higher mortality rates.[37] Moreover, particularly in the case of surgical patients, the dampened immune response and impaired wound healing increases the risk of (postoperative) infections.[38] Fortunately, various studies have shown that malnutrition is reversible with the suitable nutritional intervention; this process often requires the use of oral nutritional supplements in addition to dietary counseling.[39–42] In vascular surgery patients, a study investigating the effect of preventive nutritional measures on postoperative outcomes is currently lacking. Adequate nutritional screening can help detect patients at risk for malnutrition, thereby identifying candidates for preventive measures—potentially a combination of both nutrition and exercise interventions. Notably, in severely malnourished patients, early and adequate nutritional consultation has the potential to reduce the length of hospital stay by an average of 3.2 days.[39] Among cancer patients, nutritional treatment significantly reduced the risk of adverse events such as vomiting and gastrointestinal obstruction.[40] Additionally, preventive nutritional interventions were associated with improved functional and cognitive status in elderly at risk for malnutrition.[41] These findings, supported by our results, suggest that similar interventions might also be helpful to vascular surgery patients at risk for malnutrition, potentially reducing surgical complications and hospital length of stay, and improving functional and cognitive outcomes.

This study has some limitations that need to be addressed. First, we estimated the risk for (future) malnutrition and we did not measure present nutritional status. However, by assessing the risk, we discovered that even the presence of risk factors for future malnutrition leads to a higher risk of complications. Second, the PG-SGA SF was not previously validated within the vascular surgery setting, but a gold standard is currently lacking. Our findings suggest that preoperative screening for nutritional risk is a step in the right direction for improved individual patient care, and that, also in the vascular surgery setting, the PG-SGA SF is a valuable tool for this end. Third, the PG-SGA SF is a questionnaire that is completed by the patient individually; because of various coping strategies and/or potential cognitive impairments, problems may be under- or over-reported leading to subsequent under- or overestimation of the nutritional impairments. Fourth, the number of patients in the 3 malnutrition risk groups was not equal, where particularly in the high risk for malnutrition group the number of patients was relatively low. Because of this skewed distribution, the statistical power was limited potentially leading to an underestimation of the effect and the significance of the relationship between high risk for malnutrition and postoperative complications in the multivariate linear regression analysis. Fifth, this observational cross-sectional study took place at a tertiary referral center that provides specialized care; this may have led to inclusion of patients whose data are somewhat less generalizable to other groups or cohorts of vascular surgery patients. Finally, we chose to include all the elective surgical procedures, ranging from percutaneous interventions to open abdominal surgery. The effect of risk for malnutrition could have been more substantial in specific intervention categories. Nevertheless, after an additional analysis with only the major vascular procedures, the association between patients at medium risk for malnutrition and the risk for postoperative complications remained significant.

In conclusion, electively operated vascular surgery patients with an estimated medium risk for malnutrition are more likely to develop postoperative complications. This finding suggests that preventive measures improving the nutritional status prior to surgery has the potential to reduce the risk of complications. Future intervention studies are necessary to determine whether preventive strategies will lead to better surgical outcomes.

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REFERENCES

1. Hassen TA, Pearson S, Cowled PA, et al. Preoperative nutritional status predicts the severity of the systemic inflammatory response syndrome (SIRS) following major vascular surgery. Eur J Vasc Endovasc Surg 2007;33:696–702.
2. Leide da Silva Nunes F, Calado Ferreira Pinheiro Gadelha P, Damasceno de Souza Costa M, et al. Nutritional status and its impact on time and relocation in postoperative complications of abdominal patients undergoing surgery. Nutr Hosp 2014;30:629–35.
3. Melchior J-C, Jean-Claude M, Préaud E, et al. Clinical and economic impact of malnutrition per se on the postoperative course of colorectal cancer patients. Clin Nutr 2012;31: 896–902.
4. Thomas MN, Kufeldt J, Kisser U, et al. Effects of malnutrition on complication rates, length of hospital stay, and revenue in elective surgical patients in the G-DRG-system. Nutrition 2016;32:249–54.
5. Schwegler I, von Holzen A, Gutzwiller J-P, et al. Nutritional risk is a clinical predictor of postoperative mortality and

morbidity in surgery for colorectal cancer. Br J Surg 2010;97:92—7.
6. Fitzpatrick F, Skally M, O'Hanlon C, et al. Food for thought. Malnutrition risk associated with increased risk of healthcare-associated infection. J Hosp Infect 2019;101: 300—4.
7. Chermesh I, Hajos J, Mashiach T, et al. Malnutrition in cardiac surgery: food for thought. Eur J Prev Cardiol 2014;21: 475—83.
8. Tanaka T, Sato T, Yamashita K, et al. Effect of preoperative nutritional status on surgical site infection in colorectal cancer resection. Dig Surg 2017;34:68—77.
9. Huang T-H, Hsieh C-C, Kuo L-M, et al. Malnutrition associated with an increased risk of postoperative complications following hepatectomy in patients with hepatocellular carcinoma. HPB (Oxford) 2019;21:1150—5.
10. Salomon du Mont L, Leclerc B, Morgant M-C, et al. Impact of nutritional state on critical limb ischemia early outcomes (DENUCRITICC study). Ann Vasc Surg 2017;45:10—5.
11. Cederholm T, Barazzoni R, Austin P, et al. ESPEN guidelines on definitions and terminology of clinical nutrition. Clin Nutr 2017;36:49—64.
12. Mourão F, Amado D, Ravasco P, et al. Nutritional risk and status assessment in surgical patients: a challenge amidst plenty. Nutr Hosp 2004;19:83—8.
13. Meier RF, Forbes A. Basics in clinical medical nutrition. Nestle Nutr Inst Workshop Ser 2015;82:1—16.
14. Davenport DL, Xenos ES, Hosokawa P, et al. The influence of body mass index obesity status on vascular surgery 30-day morbidity and mortality. J Vasc Surg 2009;49:140—7.
15. Smeili LAA, Lotufo PA. Incidence and predictors of cardiovascular complications and death after vascular surgery. Arq Bras Cardiol 2015;105:510—8.
16. Gabrielson DK, Scaffidi D, Leung E, et al. Use of an abridged scored Patient-Generated Subjective Global Assessment (abPG-SGA) as a nutritional screening tool for cancer patients in an outpatient setting. Nutr Cancer 2013;65:234—9.
17. Beek LT, Banning LBD, Visser L, et al. Risk for malnutrition in patients prior to vascular surgery. Am J Surg 2017;216: 534—9.
18. The World Medical Association. WMA Declaration of Helsinki—Ethical Principles for Medical Research Involving Human Subjects. Available at, https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/. Accessed April 5, 2019.
19. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:373—83.
20. Schmolders J, Friedrich MJ, Michel R, et al. Validation of the Charlson comorbidity index in patients undergoing revision total hip arthroplasty. Int Orthop 2015;39:1771—7.
21. Olufajo OA, Reznor G, Lipsitz SR, et al. Preoperative assessment of surgical risk: creation of a scoring tool to estimate 1-year mortality after emergency abdominal surgery in the elderly patient. Am J Surg 2017;213:771—777.e1.
22. Abbott J, Teleni L, McKavanagh D, et al. Patient-Generated Subjective Global Assessment Short Form (PG-SGA SF) is a valid screening tool in chemotherapy outpatients. Support Care Cancer 2016;24:3883—7.
23. Sealy MJ, Haß U, Ottery FD, et al. Translation and cultural adaptation of the scored Patient-Generated Subjective Global Assessment: an interdisciplinary nutritional instrument appropriate for Dutch cancer patients. Cancer Nurs 2018;41:450—62.
24. Jager-Wittenaar H, Ottery FD. Assessing nutritional status in cancer: role of the Patient-Generated Subjective Global Assessment. Curr Opin Clin Nutr Metab Care 2017;20:322—9.
25. Dindo D, Demartines N, Clavien P-A. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004;240:205—13.
26. Slankamenac K, Graf R, Barkun J, et al. The comprehensive complication index: a novel continuous scale to measure surgical morbidity. Ann Surg 2013;258:1—7.
27. Williams JD, Wischmeyer PE. Assessment of perioperative nutrition practices and attitudes—a national survey of colorectal and GI surgical oncology programs. Am J Surg 2017;213:1010—8.
28. Tangvik RJ, Tell GS, Guttormsen AB, et al. Nutritional risk profile in a university hospital population. Clin Nutr 2015;34:705—11.
29. McWhirter JP, Pennington CR. Incidence and recognition of malnutrition in hospital. BMJ 1994;308:945—8.
30. Sealy MJ, Nijholt W, Stuiver MM, et al. Content validity across methods of malnutrition assessment in patients with cancer is limited. J Clin Epidemiol 2016;76:125—36.
31. Wei K, Nyunt M-S-Z, Gao Q, et al. Association of frailty and malnutrition with long-term functional and mortality outcomes among community-dwelling older adults: results from the Singapore Longitudinal Aging Study 1. JAMA Netw Open 2018;1:e180650.
32. Gupta R, Gan TJ. Preoperative nutrition and prehabilitation. Anesthesiol Clin 2016;34:143—53.
33. Levett DZH, Grocott MPW. Cardiopulmonary exercise testing, prehabilitation, and enhanced recovery after surgery (ERAS). Can J Anesth 2015;62:131—42.
34. Whittle J, Wischmeyer PE, Grocott MPW, et al. Surgical prehabilitation. Anesthesiol Clin 2018;36:567—80.
35. Kruizenga H, van Keeken S, Weijs P, et al. Undernutrition screening survey in 564,063 patients: patients with a positive undernutrition screening score stay in hospital 1.4 d longer. Am J Clin Nutr 2016;103:1026—32.
36. Álvarez-Hernández J, Planas Vila M, León-Sanz M, et al. Prevalence and costs of malnutrition in hospitalized patients; the PREDyCES Study. Nutr Hosp 2012;27:1049—59.
37. Leiva Badosa E, Badia Tahull M, Virgili Casas N, et al. Hospital malnutrition screening at admission: malnutrition increases mortality and length of stay. Nutr Hosp 2017;34:907—13.
38. Reid CL. Nutritional requirements of surgical and critically-ill patients: do we really know what they need? Proc Nutr Soc 2004;63:467—72.
39. Somanchi M, Tao X, Mullin GE. The facilitated early enteral and dietary management effectiveness trial in hospitalized patients with malnutrition. JPEN J Parenter Enteral Nutr 2011;35:209—16.
40. Pan H, Cai S, Ji J, et al. The impact of nutritional status, nutritional risk, and nutritional treatment on clinical outcome of 2248 hospitalized cancer patients: a multicenter, prospective cohort study in Chinese teaching hospitals. Nutr Cancer 2013;65:62—70.
41. Poscia A, Milovanovic S, La Milia DI, et al. Effectiveness of nutritional interventions addressed to elderly persons: umbrella systematic review with meta-analysis. Eur J Public Health 2018;28:275—83.
42. Baldwin C, Weekes CE. Dietary counselling with or without oral nutritional supplements in the management of malnourished patients: a systematic review and meta-analysis of randomised controlled trials. J Hum Nutr Diet 2012;25:411—26.